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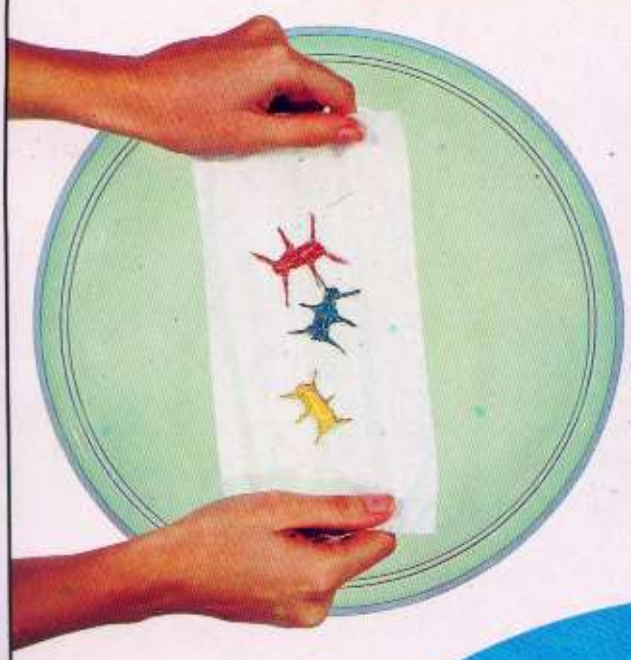
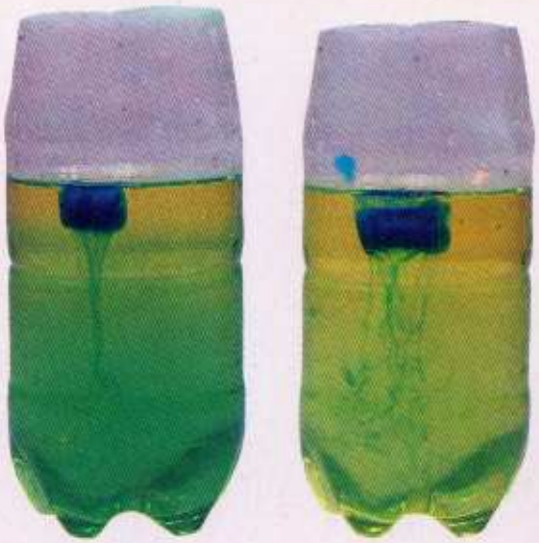
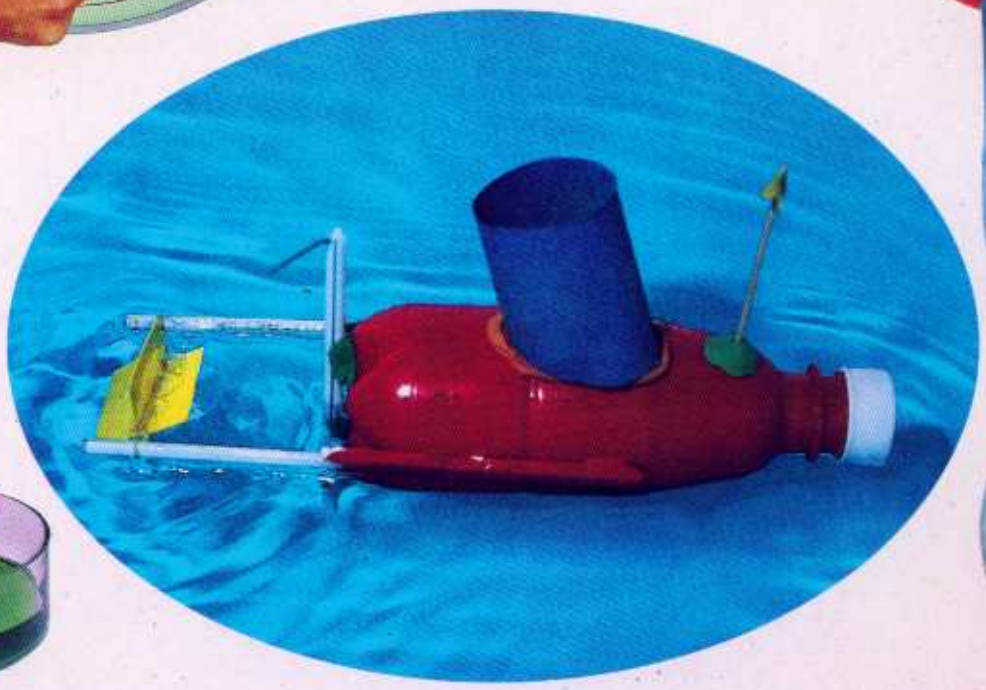
Science • Experiments

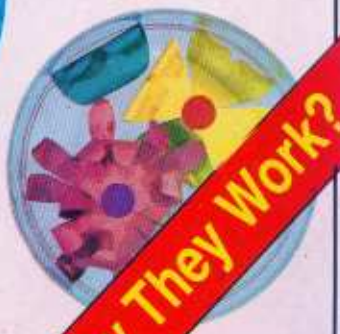
WATER · PADDLES & BOATS

In Colour









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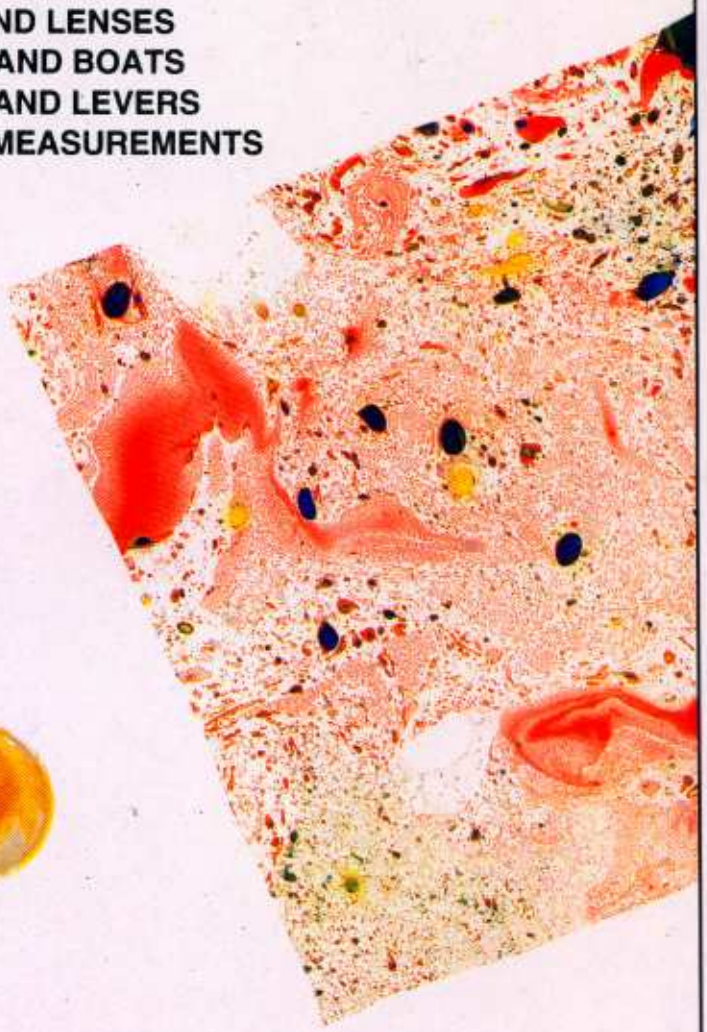

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Science • Experiments

WATER • PADDLES & BOATS

Pam Robson

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PHOTOCREDITS

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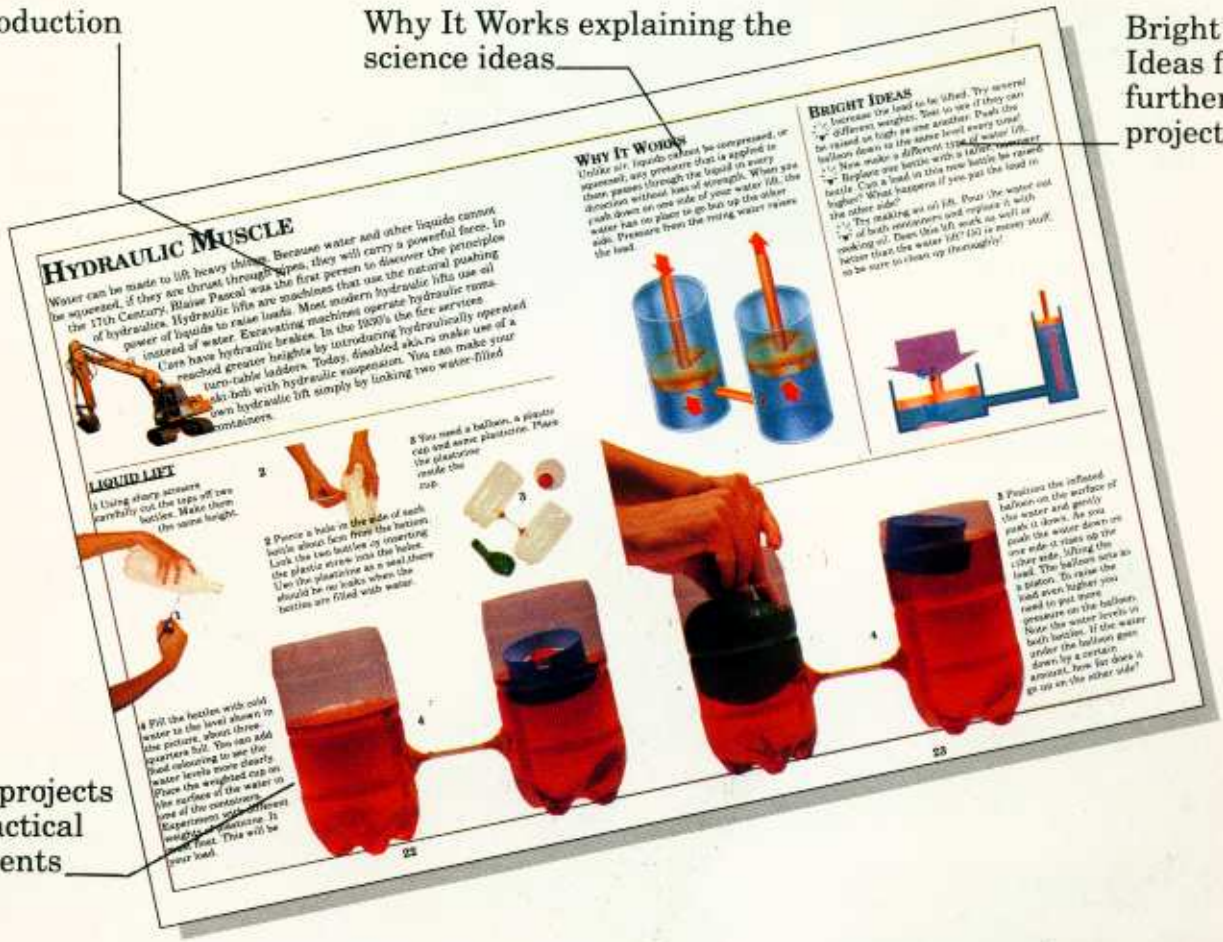
INTRODUCTION

Water is familiar to all of us. Yet it has some strange and beautiful properties. It can stretch and curve. It occurs naturally as solid, liquid and gas. Sometimes it flows uphill. Most substances, when cooled, contract, whereas water expands. Hence thus an ice cube fills more space than it did before freezing. At boiling point, 100°C, water turns to steam, but it requires an unusually large amount of heat for this transformation. That is why steam has got plenty of energy. Harnessed water power is a priceless resource in an age when people must conserve fuel. From the simple wooden water-wheel, engineers have developed the water and steam turbines. These gigantic machines operate generators that provide us with hydro-electric power and sufficient propulsion to drive huge oil tankers. The unharnessed power of water has shaped the face of the Earth since time immemorial, carving valleys and coastlines, re-shaping and dissolving rocks — even transporting them. The terrible force of tidal waves can unleash devastation for coastal communities. Water covers almost three-quarters of our planet. Made of hydrogen and oxygen, it is the most common compound. However, simple and plentiful, water is precious and essential to all living things.



THE LABORATORY

A science laboratory is a place to test ideas, perform experiments and make discoveries. To prove many scientific facts you don't need a lot of fancy equipment. In fact, everything you need for a small laboratory can be found around your home or school. Read through these pages, and then use your imagination to add to your "home laboratory". Make sure that you are aware of relevant safety rules, and look after the environment. A science experiment is an activity that involves the use of certain basic rules to test an hypothesis. A qualitative approach involves observation. A quantitative approach involves measurement. Remember, one of the keys to being a creative scientist is to keep experimenting. This means experimenting with equipment to give you the most accurate results as well as experimenting with ideas. In this way you will build up your laboratory as you go along.

MAKING THE MODELS

Before you begin, read through all the steps. Then make a list of the things you need and collect them together. Next, think about the project so that you have a clear idea of what you are about to do. Finally, take your time in putting the pieces together. You will find that your projects work best if you wait while glue dries or water heats. If something goes wrong, retrace your steps. And, if you can't fix it, start all over again. Every scientist makes mistakes, but the best ones know when to begin again!

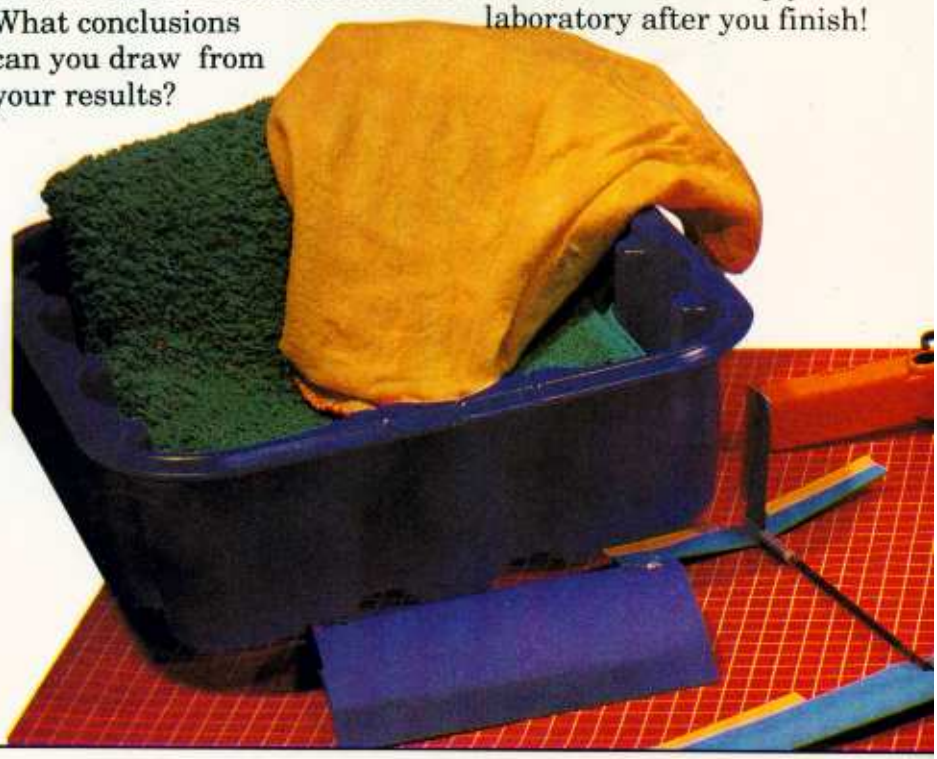
GENERAL TIPS

There are at least two parts to every experiment: experimenting with materials and testing a science "fact". If you don't have all the materials, experiment with others instead. For example, try a plastic drinks bottle if you can't find a liquid detergent bottle.

Once you've finished experimenting, read your notes thoroughly, think about what happened, and evaluate your measurements and observations. What conclusions can you draw from your results?

SAFETY WARNINGS

Make sure that an adult knows what you are doing at all times. Many of these models are made from plastic bottles. Make sure you don't use inflammable materials; like plastic, where heating is involved. Always be very careful when cutting them with scissors. If you spill any water, wipe it up right away. Slippery surfaces can be dangerous. Clean up your laboratory after you finish!



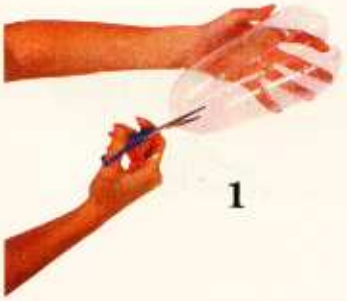
Experimenting

Always conduct a "fair test". This means changing one thing at a time in each stage of an experiment. In this way you can always tell which change caused a different result. As you go along, record what you see and measure. Ask questions such as "why"? "how?" and "what if?" Then test your model and write down the answers you arrive at.

WATER'S CYCLE

Whether falling from a cloud, spurting from a kitchen tap or springing out from underground, water moves in an endless cycle between Earth and sky. Year after year, the Sun performs a fantastic feat; its energy evaporates 400,000 cubic kilometres of water from oceans, rivers, lakes and streams. Rain and snow bring this water back to Earth. The water cycle is a chain of evaporation and condensation in which water turns to vapour and back to liquid again. Heat accelerates evaporation; cooling leads to condensation. You can model this cycle using hot water and ice.

CLOUDBURST



1

1. Clean a plastic drinks bottle and remove the label. With scissors, carefully cut off the neck and make a wide opening down one side. The opening must be big enough for ice cubes. (Put these in last.)

6

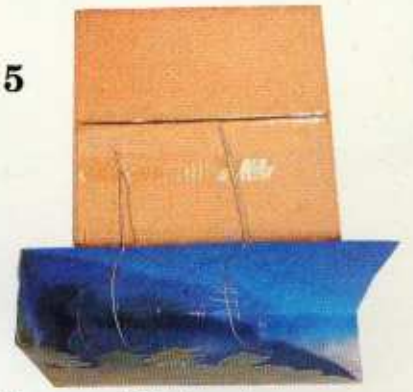
2

2. From an empty cereal box, cut out the forested mountain slope shown here. Make the front tree section lower than the rear sky section. Paint the scene to look like a real mountainside.

3. Make sure that the bottle fits inside the box as shown. It will be your cloud.

3

5



4. Ask an adult to cut a wire coat hanger into two lengths. Curve each piece of wire to fit around the plastic bottle. These metal loops will support the ice-filled bottle.

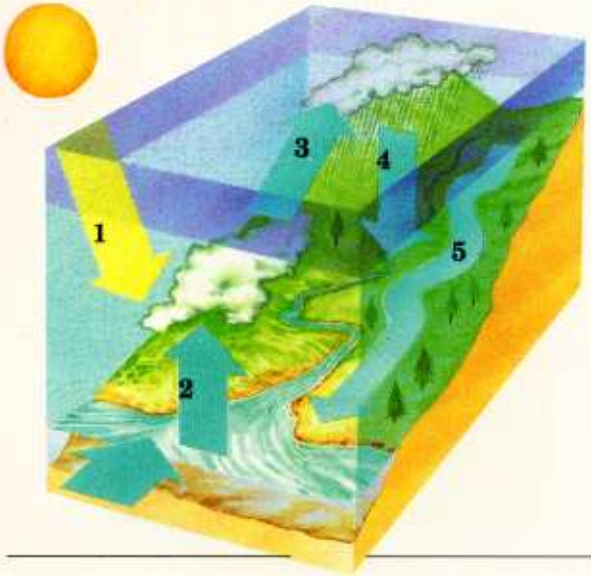
6. Place an aluminium foil dish inside the bottom of the cereal box as shown. Fill the dish with hot water from a kettle. Be careful!

5. Place another sturdy box behind your mountain-scape. (It should be the same height.) Sellotape the wire "handles" to the top of this box.

4

Why It Works

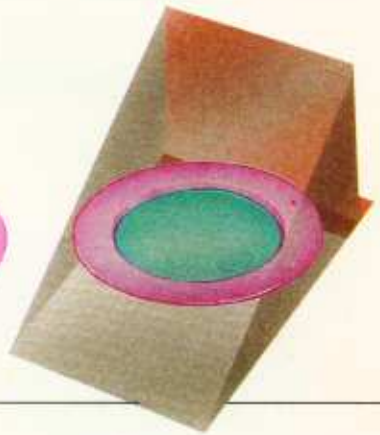
The sun's heat (1). fills molecules, or tiny particles, of surface water with energy causing them to split from the mass of water and escape into the air as water vapours (2). Trapped in the cool air, they condense around dust particles as droplets of water. These droplets join as the air cools, forming clouds (3). When the drops become two big and heavy to stay in the air, rain falls (4). The rain water runs off the land back into the sea in rivers and streams (5).



Bright Ideas

Measure rainfall with a rain gauge. Carefully cut the top off a liquid detergent bottle and set it upside down inside the bottom half like a funnel. Mark millimetre divisions from the bottom of the container. Stand it outside in an exposed place. Keep a daily record. Remember to empty the rain gauge every time.

Take two bowls filled to the brim with water. Stand one in a sunny place, the other in the shade. Compare the water levels at the end of each day to measure evaporation.



7

7. As the water evaporates from the dish, water vapours will rise and cool. As they cool, they will condense on the plastic ice-filled bottle. Rain and fall!

Freezing and Melting

Not only does water appear as liquid and vapour; when it is cooled to the freezing point, it turns into a solid as well. Unlike most substances which shrink when they turn from liquid to solid, water expands. Water is denser then ice. That is why in cold areas, in winter, pipes burst through the expansion of freezing water. Icebergs also give a good clue to the freezing and melting of water. These huge islands of ice adrift in polar seas have broken off into the sea from vast glaciers or rivers of ice. As ice is ten per cent less dense than water, the top of an iceberg is only one-tenth of the total size of the iceberg. The project below shows how ice floats and how water behaves as it melts.

MELTING ICEBERG

1. Clean a plastic drinks bottle and remove the label. With a sharp scissors carefully cut off the top.

1

2

2. Almost fill a plastic bottle with cold water. Add a few drops of food colouring. Shake the bottle to mix the colour well.

3. Pour this coloured water into an ice-cube tray. Leave the tray in a freezer to freeze overnight.

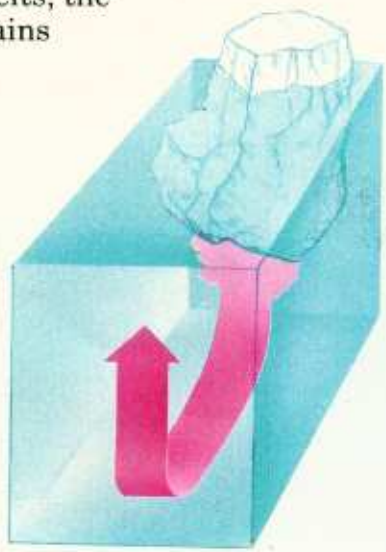
3

4. Pour hot tap water into the large plastic bottle. Add a different colour and stir.

4

Why It Works

When the ice cube melts, the water sinks as it regains its original density. Also cold water is denser, or heavier, than hot water, and sinks below it. This also causes the cold water melting from the ice cube to sink first to the bottom of the bottle.



Bright Ideas

Fill a small plastic bottle to the brim with water and place it uncovered in the freezer. Wait for the water to freeze. Which takes up more space, the same quantity of liquid water or the water when frozen? Can you measure the difference?

Float an ice-cube in a full glass of water. Do you expect the glass to overflow as the ice melts?

5. Drop a coloured ice cube in the hot water. Since ice is less dense than water, it will float.

5

6. Watch the water melting off the ice. This water swirls and sinks as it regains its liquid density.

6

SALTY SOLUTIONS

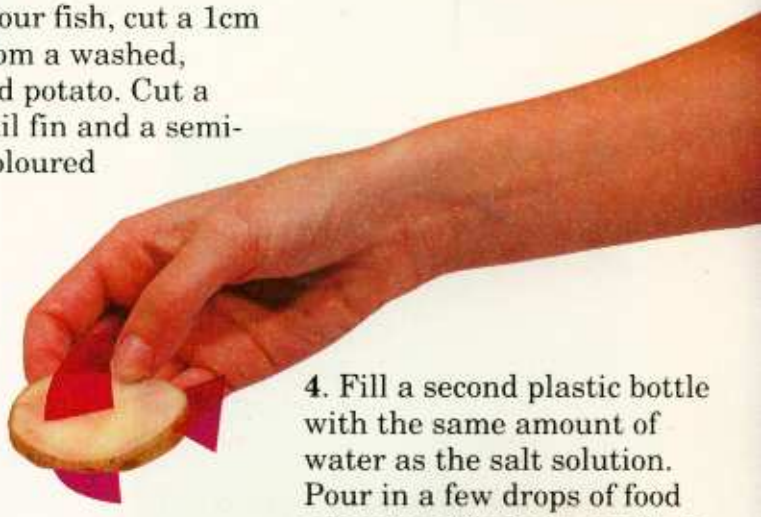
Most water on the Earth's surface is salty due to minerals washed out of rocks by pounding rain and rushing rivers. One such mineral is sodium chloride, or common salt. Salt water is buoyant, which means it can hold things up. It helps boats to float better than they would in fresh water. Israel's Dead Sea, shown here, is too salty for fish but ideal for floating. Salt water is more buoyant because the molecules of salt and water are joined tightly together. You can try to float things in both salt and tap water to see how these tightly knit molecules hold things up better than loosely linked fresh water molecules.

FLOATING FISH

1

1. To make your fish, cut a 1cm thick slice from a washed, medium-sized potato. Cut a triangular tail fin and a semi-circle from coloured cellophane.

2



2. Get an adult to help you make a slit in the potato circle from the centre towards the edge. Push the cellophane semicircle through to make balancing fins. Cut another slit along the potato peel for the tail.

3

3. To make salty water, drop at least 8 large spoonfuls of salt in a plastic bottle three-quarters full of cold water. (Note whether there is a change in the water level.) Stir the solution with a straw till no more salt dissolves.

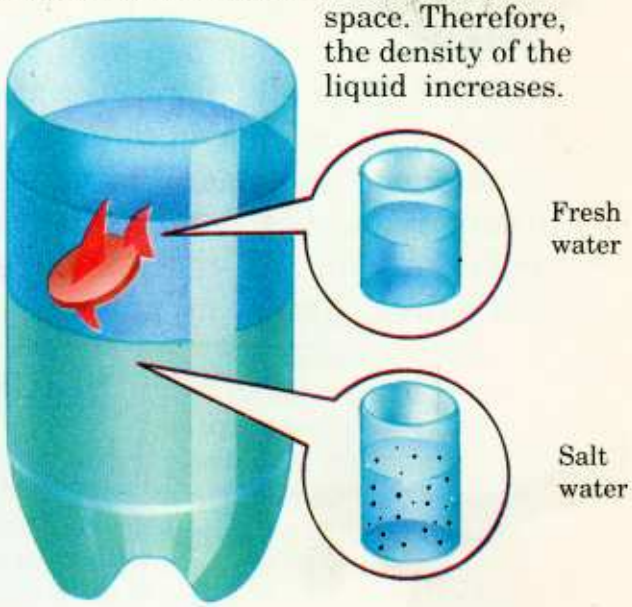
4. Fill a second plastic bottle with the same amount of water as the salt solution. Pour in a few drops of food colouring. Shake it gently to mix the colour well.

4

5. Pour the salt solution into a clear bottle from which the top has been cut. Slowly add the coloured water by pouring it over the back of a spoon. Place your fish on the water's surface. It will sink no deeper than the surface of salt water.

Why It Works

Your fish floats in salt water, yet sinks in fresh water. This is because the density of the fish is less than the density of salt water, but more than that of fresh water. When you pour salt crystals into the water, the water level does not go up. Instead the salt dissolves and the mixture fills the same space. Therefore, the density of the liquid increases.



Bright Ideas

You can get the salt back out of the water. Boil your solution dry in a saucepan. Be very careful! The salt is left behind. Carefully trap some of the vapour from the boiling solution with the back of a spoon. Watch it condense. The drops of water will be salt-free. Pour all the salt from a salt cellar into a full glass of water. Do you expect the water to overflow?

Floating Liquids

On a rainy day you often see oil shimmering on a puddle of water. Like certain objects, liquids too can float on other liquids, forming layers as in a salad dressing bottle. Light liquids float on heavier liquids. Salad oil floats on vinegar because the salad oil is less dense. Mustard is often added to mix the two solutions as it acts as an emulsifier. Most oils float on water too. Oil spills can blacken the surface of thousands of miles of water, devastating entire ocean regions and coastlines, and killing many acquatic creatures. One way to disperse a slick, and make it mix with water, is to spray it with detergent. You can capture the effect of an oil spill with oil-based paints, water and paper.

SLICK PICTURES

1

1. To make your oil slick pictures you will need some oil-based paints, thinned with turpentine. Choose bright colours to make exciting prints.

2

2. Fill a deep plastic bowl with cold water. Make sure the bowl is bigger than the sheets of paper you are using for your pictures. (You can add a few drops of vinegar to the water.) Drop small amounts of paint onto the surface of the water.

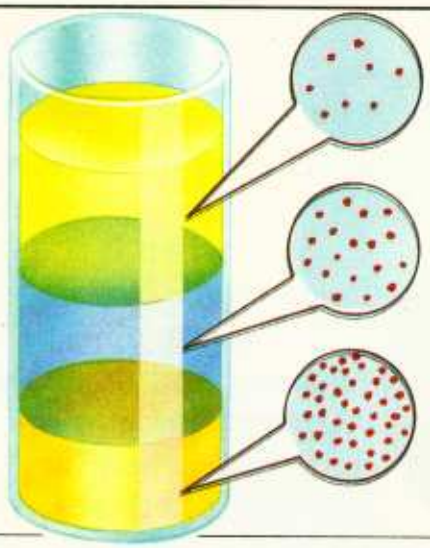
3. Using a clean stick, swirl the colours around. Do this gently on the water's surface. You can make lots of different patterns. When you have made a pattern that you really like, you are ready to capture it as a picture on white paper.

3

4. Lower one sheet of clean, strong paper on top of the paint. Make sure there are no air bubbles. Allow the paint to soak in for a few minutes. Carefully lift the paper off again. Place it on some newspaper to dry.

Why It Works

Your paints float on the surface because they are less dense than the water below. Liquids of different densities form different layers in a container, the least dense sitting at the top. To mix the liquids, an emulsifier splits the top layer into tiny droplets that cascade into the layer below. Detergent is an emulsifier that allows oil and water to mix.

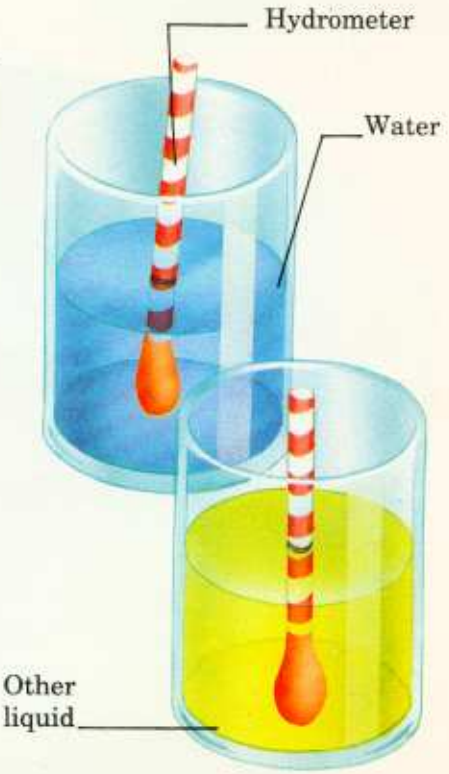


5

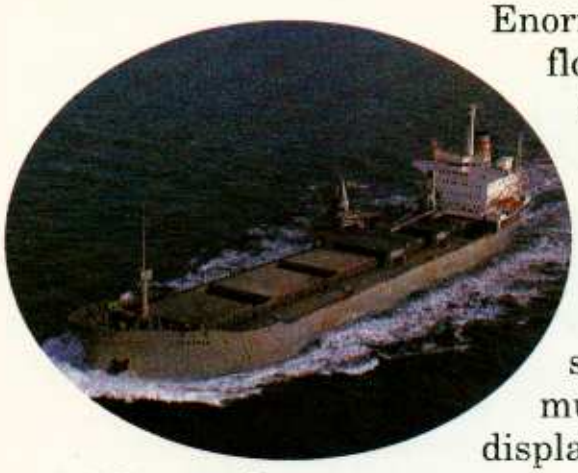
5. You can keep making pictures until all the paint is used up. The more pictures you make, the paler the colours will become. Experiment with new designs and colours by dropping more paint onto the surface.

Bright Ideas

- Try pulling the blank paper through the surface paint and wiggling it as you do so. You will have a pattern on both sides of the paper.
- Squeeze a few drops of liquid detergent on to the surface of the paints. How does this change your marbling pattern?
- Pour some oil gently on to the surface of cold water in a screw-top jar. Add liquid detergent and shake vigorously. What has happened to the two layers in the jar?
- To measure the density of liquids, make an hydrometer with a plastic straw and some plasticine. Adjust the ball of plasticine on the bottom of the straw until it will float upright in water. Make a mark on the straw at the surface of the water. Now float it in other liquids and observe the change in levels.



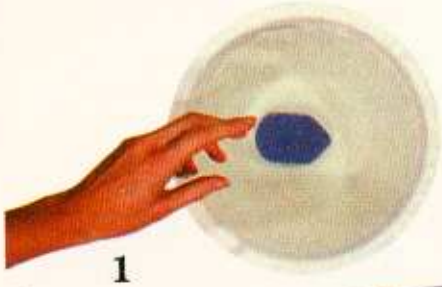
FLOAT OR SINK?



Enormous aircraft carriers and luxury cruise ships float on water, yet a small metal screw will sink! Clearly, when it comes to floating, size is not important. Nor necessarily is weight. Instead, whether an object floats or sinks depends on its density and its shape. A Greek mathematician, Archimedes, noticed that the water level in the bath rose when he got in. He concluded that for something to float the upward push of the water must be the same as the weight of the water displaced, or pushed aside, by the object. With objects of different shapes, you can test the rules of floating and sinking.

CRAFTY VESSELS

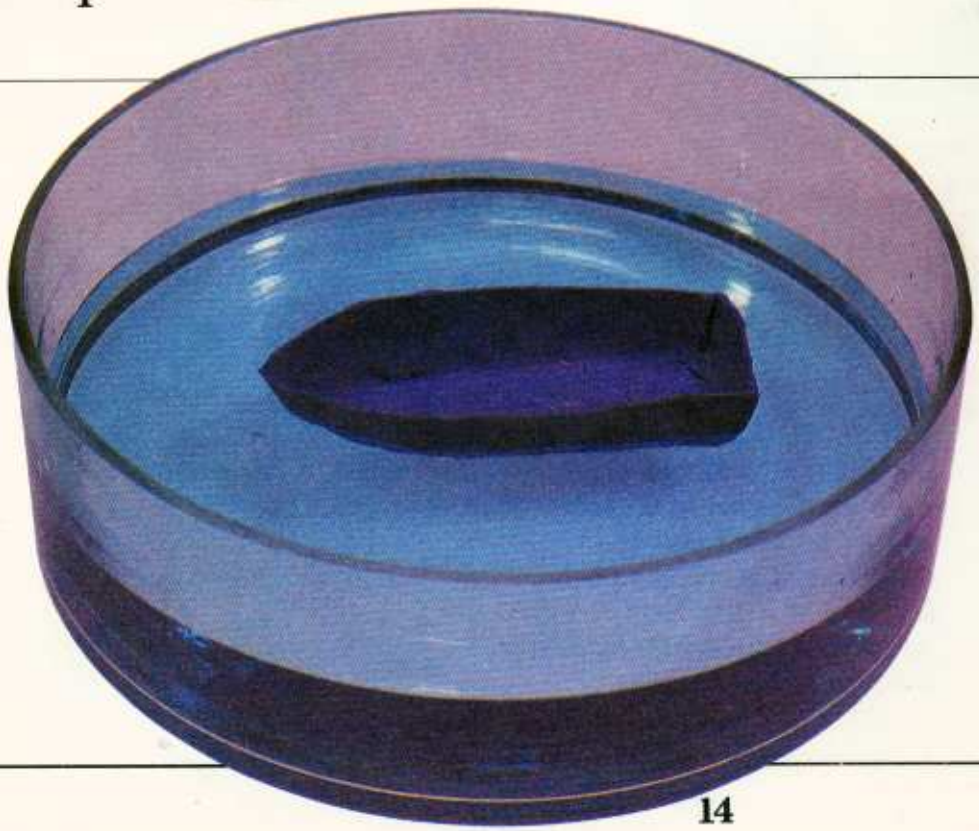
1. Mould some plasticine into a solid shape. Drop it into a dish of cold water. Watch it sink to the bottom of the dish. Try other solid shapes such as a ball.



2. Now use your hands or a rolling pin to roll the plasticine flat. Curve the edges up to make a boat. Be sure that there are no holes; otherwise it will leak.

1

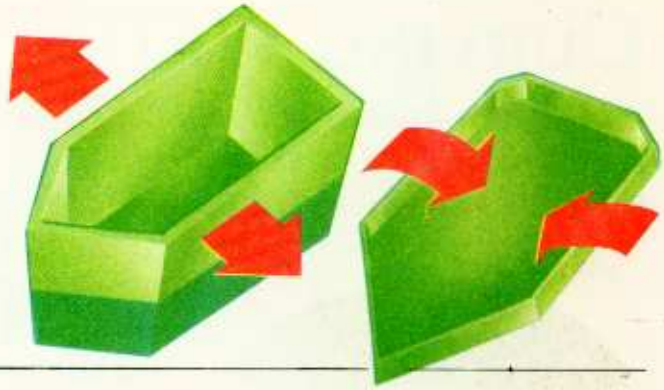
2

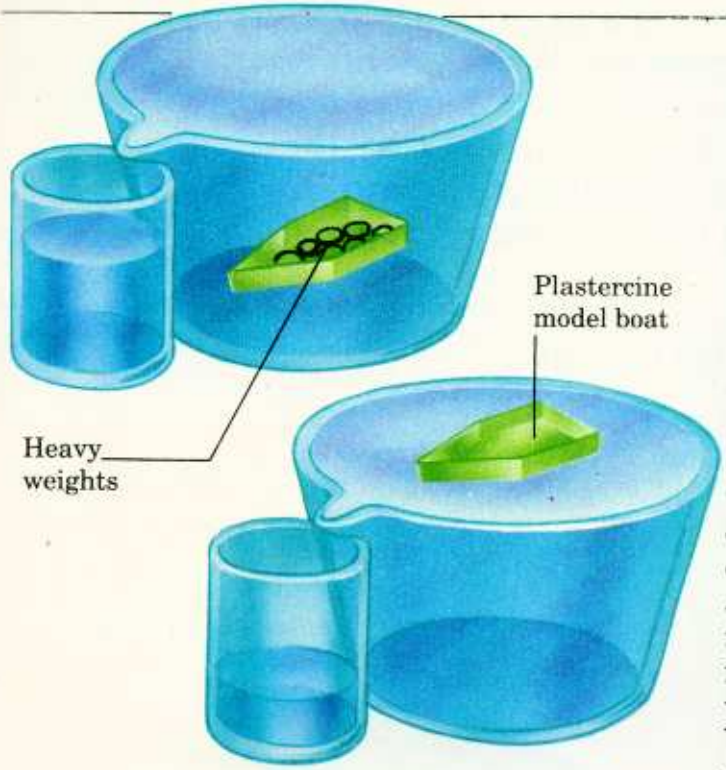


3. Half fill a shallow dish with cold water. Gently place your boat on the surface of the water. It will float easily unless there is a leak. Check how low in the water your boat sits. Mark a water level line on the side of the boat. If you want the boat to carry a load safely, it must sit high in the water.

Bright Ideas

Can you make your boat even more sea-worthy? Mould different shapes. A high-sided shape floats better than a shallow one. Have you made a long-shaped boat and a round-shaped one? How many passengers will your boat carry? Try different loads. Mark a safe water level on your craft. This is called a plimsoll line after Samuel Plimsoll.





Why It Works

When you drop a solid piece of plasticine into the water, it sinks. But when you hollow out the same piece of plasticine, it floats. This is because by making a boat shape, you change the density of the solid piece. Solid plasticine is more dense than water and therefore sinks. But the boat shape holds air which is less dense than water. This reduces the overall density of the boat to less than that of water, thus allowing it to float. An object's shape controls the amount of water it pushes out of the way. If the amount of water pushed aside, or displaced, weighs the same or more than the object, then the object will float. If the amount of displaced water weighs less than the object, it will sink. You can test this by comparing the weights of floating and over-loaded boats to the weights of the water they displace.

4

4. Now make a plasticine passenger. Sit your passenger in the middle of the boat so that it doesn't tip over. (The one shown here is gripping the sides to stay balanced.) Put the boat back in the water and watch it float with the new load. The water level will change. Does it sit lower in the water than the empty boat?

Curving Water

A glass of water can be more than full without overflowing. The water seems to puff above the rim of the glass as if it is being held by an invisible skin. Dew drops on a leaf appear to have this skin and so does water at the surface of a still pond. A water skater can glide at great speed over this taut film on the top of water. If you dip the bristles of a paint brush in water they will spread out. When you lift it out again, they pull together. Each of these effects arise from surface tension, the force between molecules at the surface of water. You can test its strength yourself.

WATER WALKERS

1. To make your water insects, you will need some light-weight aluminium foil and some paper clips. Use sharp scissors to cut the foil into small pieces, one for each paper clip. Make a number of insects for the experiment. You can also vary the size of your insects.

1

2. Place a paper clip in the middle of one half of each piece of foil. Fold over the other half of the foil so that the paper clip is enclosed. With your fingers, shape six legs on each insect. Look at the insects in the picture opposite.

2

3. Half fill a shallow dish with cold water. Very gently lower each insect onto the water's surface.

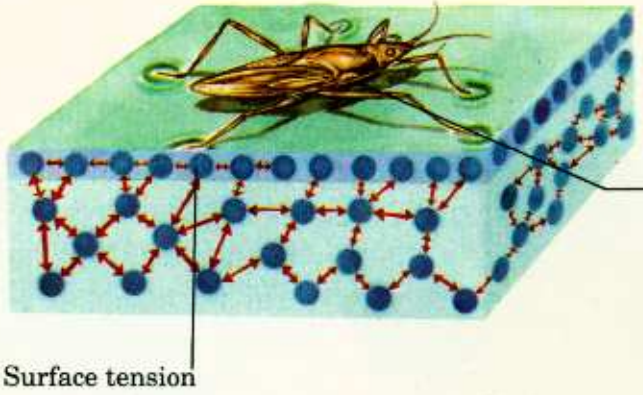
3

4. You can position all of your insects on the water at once. To do this you need a paper tissue. Place your insects on the tissue. Holding it firmly at each end, lower the tissue until it rests on the surface of the water.

4

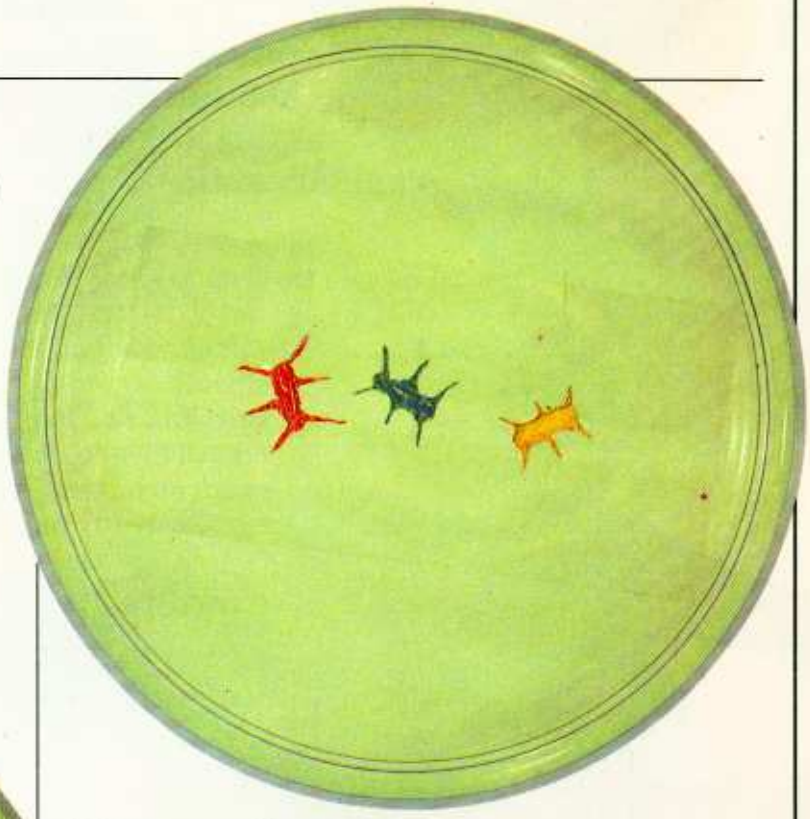
Why It Works

Water molecules attract each other. Surface molecules have no water molecules attracting them from above and therefore they pull together. The result is a force called surface tension — strong enough to support certain insects. Liquid detergent reduces this surface tension by breaking down the force of attraction between the water molecules.



6. When the water is still, carefully drop some liquid detergent on to the surface, just behind each insect. Watch them dart about! To repeat, you need fresh water.

5. The tissue will soak up water and gradually sink to the bottom. But the insects will rest on the surface. Before making your insects dart over the water, make sure that the liquid is absolutely still.



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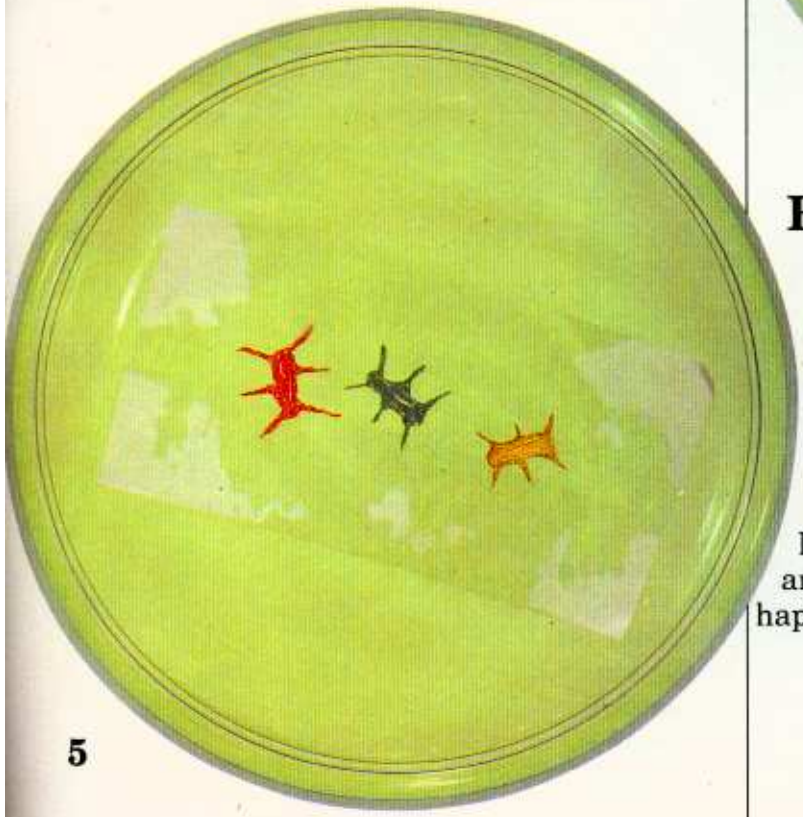
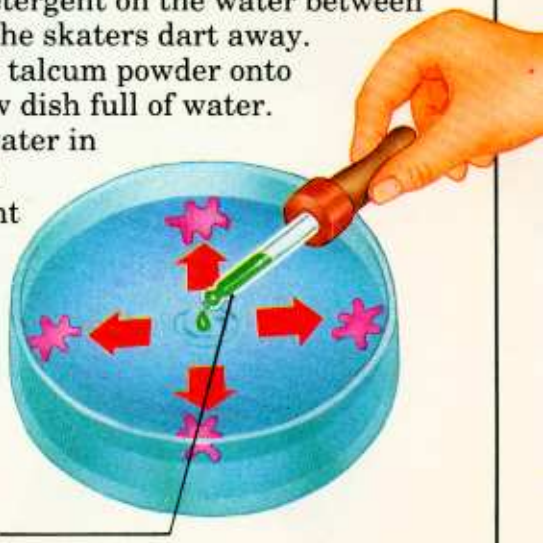


5

Bright Ideas

Float your insects together in the centre of the bowl and carefully drop some liquid detergent on the water between them. Watch the skaters dart away.

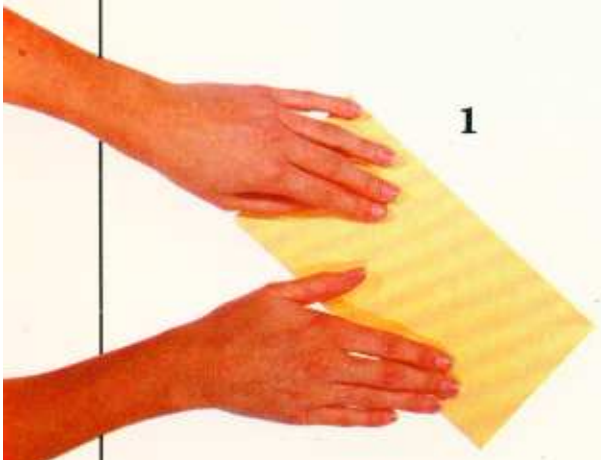
Sprinkle talcum powder onto a shallow dish full of water. Touch the water in one spot with liquid detergent and see what happens.



Rising Action

An invisible force called gravity pulls everything towards the Earth. However, in certain circumstances, water can move against this force. Plants and trees contain tubes through which water is drawn upwards, from the roots to the leaves and flowers. In the same way, flowers in a vase take up water through their stems. This process is called capillary action. You can make a closed paper flower unfurl its petals by using the force of capillary action.

PAPER PETALS



1

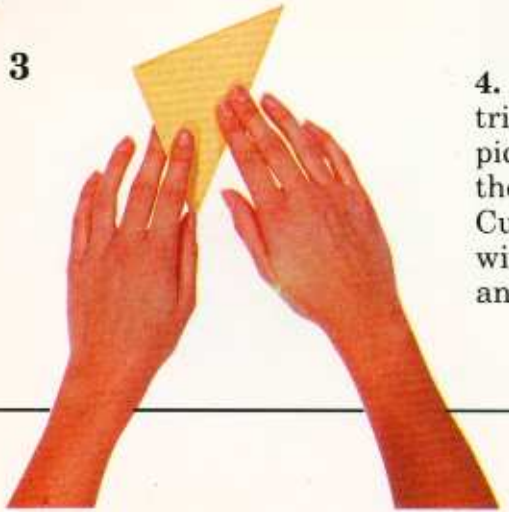
1. Take a square piece of smooth writing paper or thin card and fold it in half lengthwise to make a shape twice as long as it is wide. Do not use shiny paper.

2. and **3.** Fold your rectangular shape in half so that it forms a square. Now fold your square diagonally to make a triangle.

2

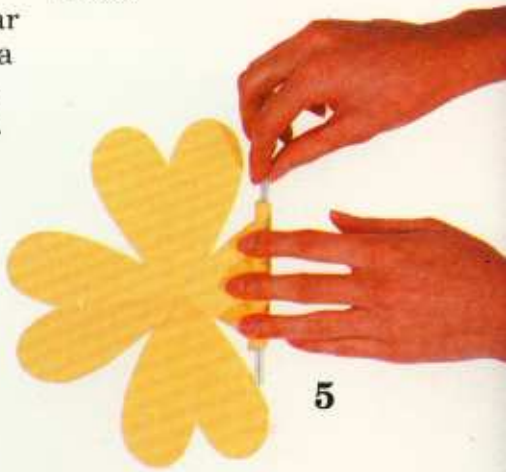
4

4. Draw a petal shape on your triangle as shown in the picture. The straight edge is the thickest fold in the paper. Cut your shape out carefully with sharp scissors. Open it up and you will have a flower.



3

5. Flower roll up each petal with a pencil to make each petal curl tightly. Your flower is now closed up. Make two or three flowers. Experiment with different shapes and sizes.



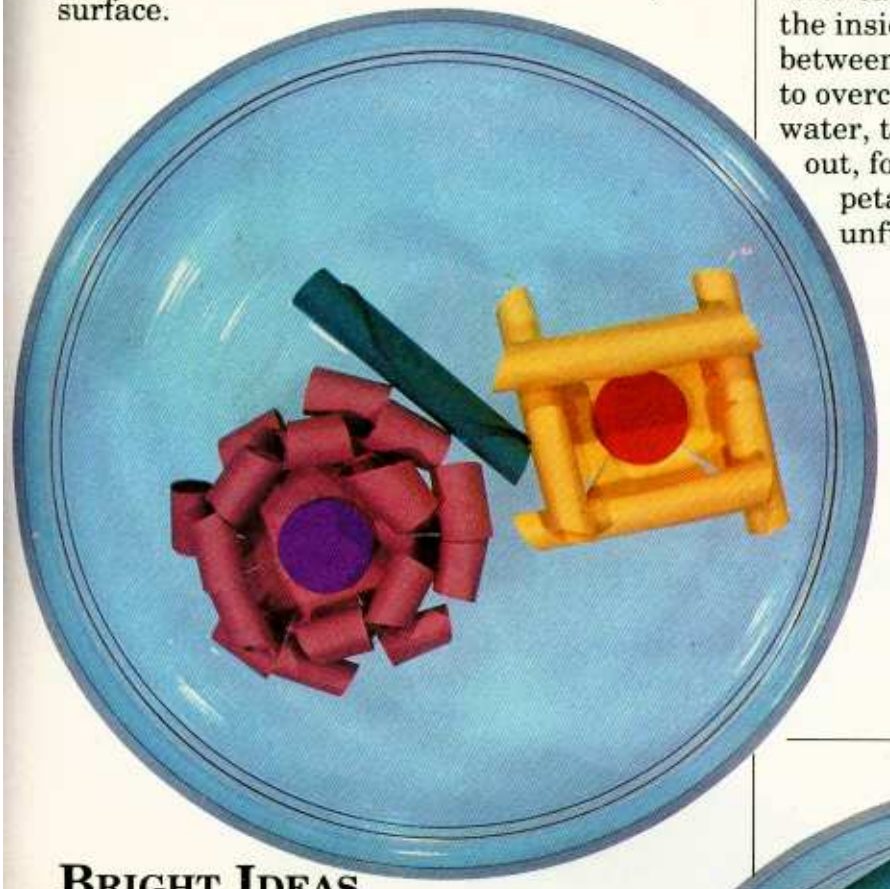
5

6. Brighten up your flower by decorating it. This one has a red circle glued in the centre.

6

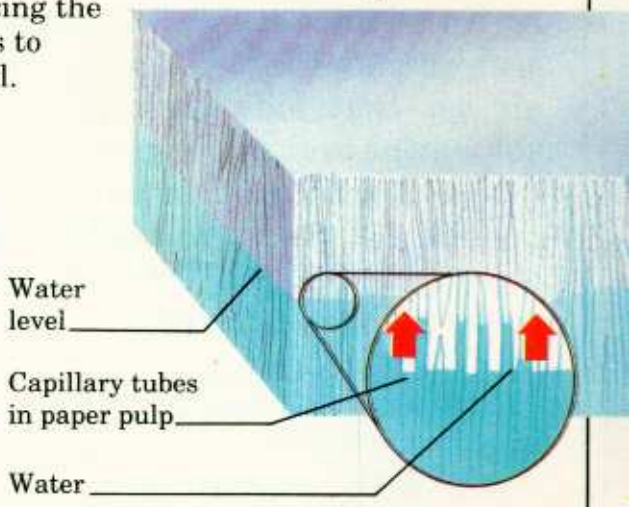
7. Fill a shallow bowl with clean, cold water. Gently place your flower on the surface.

7



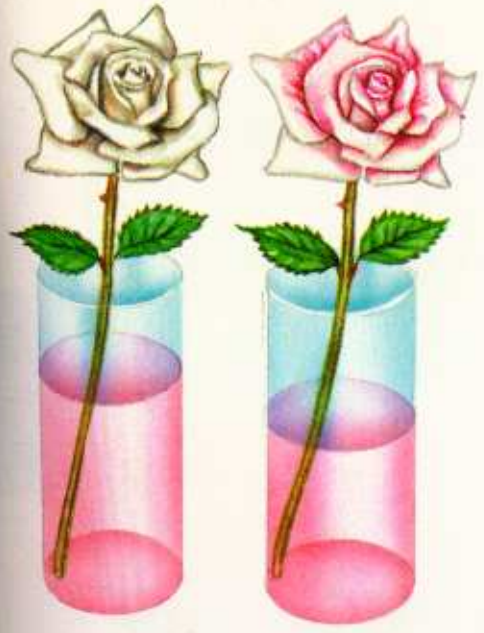
Why It Works

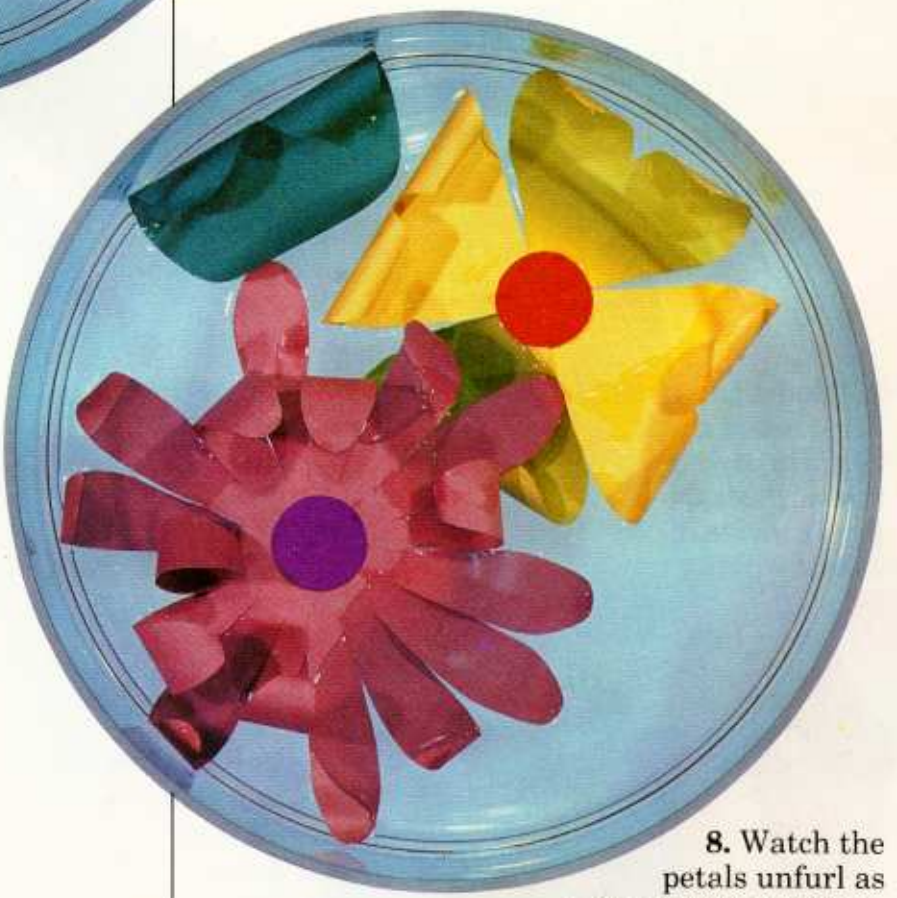
Water is drawn up into plant fibres due to a force called capillary action. The water wets the inside of the tubes and the surface tension between different molecules is forceful enough to overcome gravity. As the tubes fill with water, they become firmer and straighten out, forcing the petals to unfurl.



Bright Ideas

You can make a white flower change colour by standing it in water mixed with food colouring. By splitting a stem, can you create a two-coloured flower?





8

8. Watch the petals unfurl as water seeps into the paper. The water opens the petals.

Diving Deep

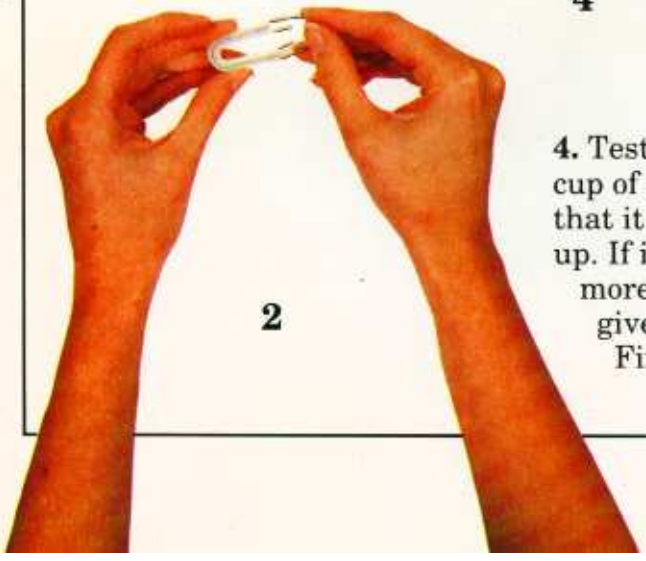
Submarines were once mentioned only in science fiction. Today, underwater vehicles map the ocean floor, repair oil rigs, and fire torpedoes during a war. They are indeed a home for aquanauts beneath the sea! To dive and resurface, submarines have borrowed their design from nature. Some jellyfish, usually seen on the surface, can sink into the deep by deflating the air sac that aids their propulsion. In the same way, submarine tanks take in water to go down and pump it out to rise up again. This kind of diving and resurfacing is possible because water is heavier than air, and water-filled objects always sink. Try it yourself with a jellyfish that takes in water to dive and expels it to resurface.

Plunging Jellyfish

1. To make the jellyfish, you will need a flexible plastic straw, a paper clip and some plasticine. Bend the ribbed part of the straw and cut the long side to the same length as the short side.

1

2. Bend a paper clip as shown here. Insert the bent paper clip into each end of the straw. Push the paper clip firmly inside, making sure that it will not slide out.



2

3. Roll out three thin strips of plasticine. Loop and pinch each one around the paper clip.

3

4

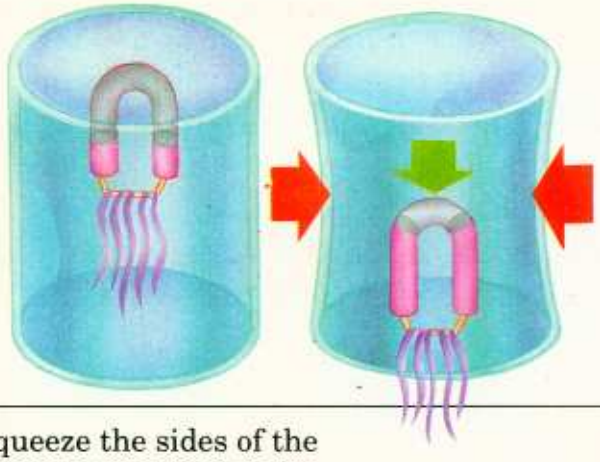
4. Test your jellyfish in a clear cup of water to make sure that it will float the right way up. If it doesn't, try adding more plasticine. This will give it weight and balance. Fix it to sit as shown here.

5. Float your jellyfish in a large plastic bottle full of water. Screw on the top.

5

Why It Works

When you squeeze the bottle, water is pushed into the plastic straw compressing the air. Because water weighs more than air, the jellyfish gets heavier, causing it to sink.



Bright Ideas

Instead of using a screw-top bottle, use a deep plastic container to house your jellyfish. Stretch a thin rubber sheet over the top and secure it with an elastic band. Apply some pressure to the rubber sheet. Which works best?

Make a deep sea diver, using an eye dropper partially filled with water.

Float a plastic bottle filled with varying amounts of water. Fill it half full or three-quarters full. See how easy it is to submerge with these different amounts of water.

6. Squeeze the sides of the plastic bottle hard. The jellyfish will sink to the bottom as water enters the straw, compressing the air inside it. This makes the jellyfish heavier.

6

7. Releasing the pressure on the sides of the bottle allows the jellyfish to rise to the surface again. The compressed air inside the straw expands again, forcing the water back out. The jellyfish becomes lighter and so more buoyant.

7

Hydraulic Muscle

Water can be made to lift heavy things. Because water and other liquids cannot be squeezed, they carry a powerful force when they are thrust through pipes. In the seventeenth century, Blaise Pascal was the first person to discover the principles of hydraulics. Hydraulic lifts are machines that use the pushing power of liquids to raise loads. Most modern hydraulic lifts use oil instead of water. Excavating machines operate hydraulic rams. Cars have hydraulic brakes. In the 1930's, the fire services reached greater heights by introducing hydraulically operated turn-table ladders. Today, disabled skiers make use of a skibob with hydraulic suspension. You can make your own hydraulic lift simply by linking two water-filled containers.

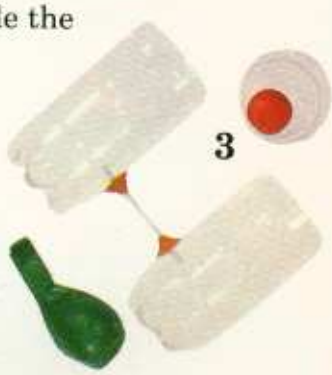
LIQUID LIFT

1. Using sharp scissors, carefully cut the tops off two bottles. Make them the same height.

2.

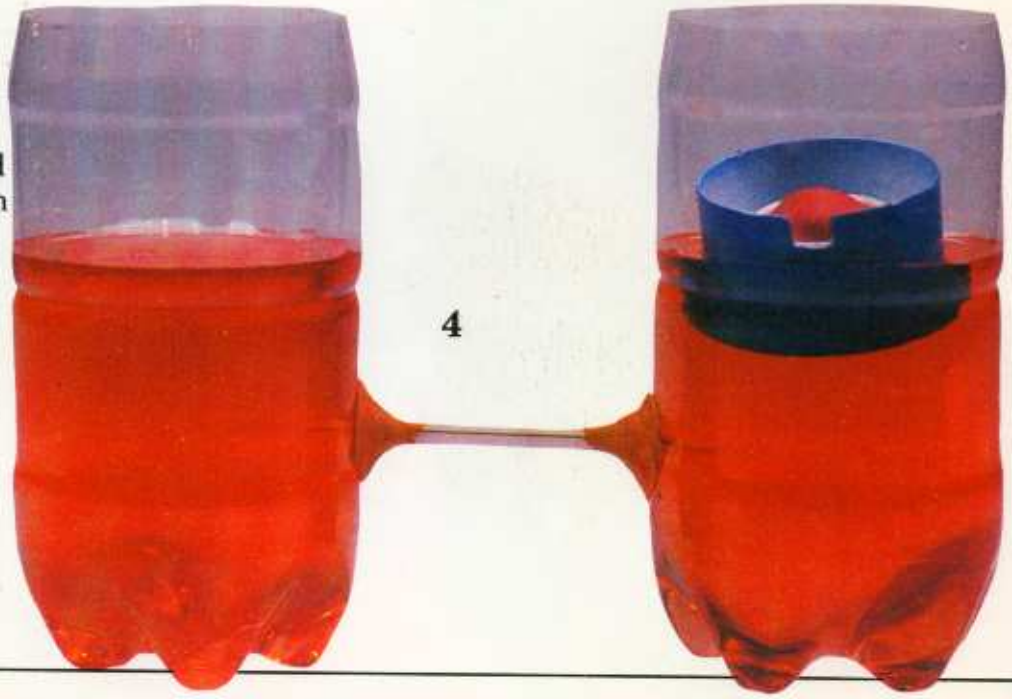
2. Pierce a hole in the side of each bottle about 5cm from the bottom. Link the two bottles by inserting the plastic straw into the holes. Use the plasticine as a seal; there should be no leaks when the bottles are filled with water.

3. You need a balloon, a plastic cup and some plasticine. Peace the plasticine inside the cup.



3.

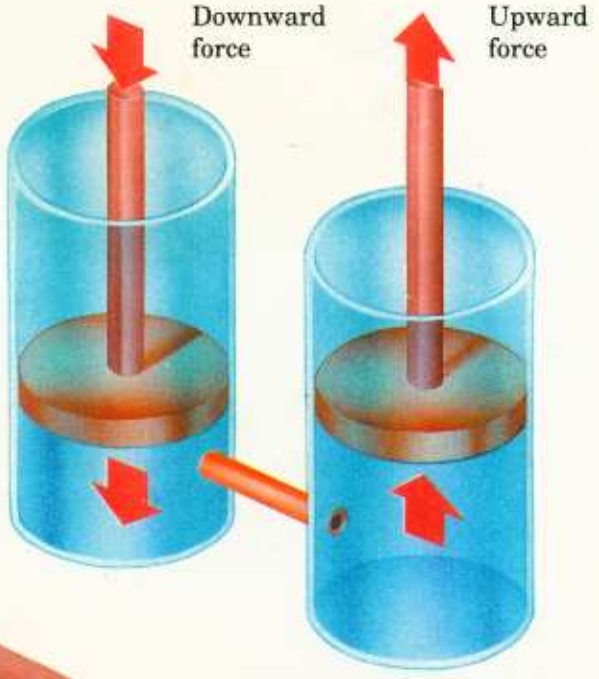
4. Fill the bottles with cold water to the level shown in the picture, about three-quarters full. You can add food colouring to see the water levels more clearly. Place the weighted cup on the surface of the water in one of the containers. Experiment with different weights of plasticine. It must float. This will be your load.



4.

Why It Works

Unlike air, liquids cannot be compressed, or squeezed; any pressure that is applied to them passes through the liquid in every direction without loss of strength. When you push down on one side of your water lift, the water has no place to go but up the other side. Pressure from the rising water raises the load.

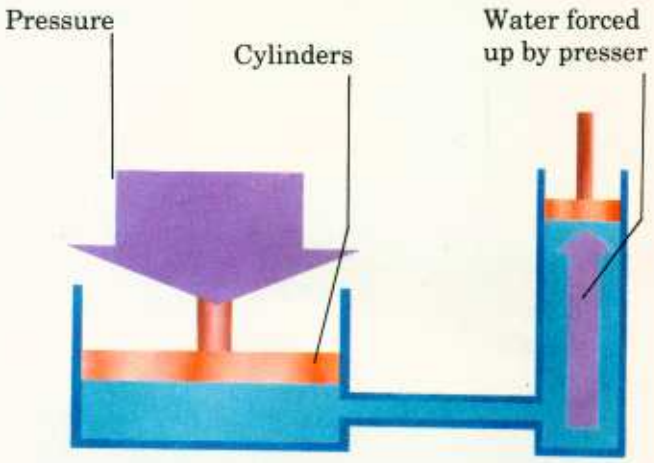


Bright Ideas

Increase the load to be lifted. Try several different weights. Test to see if they can be raised as high as one another. Push the balloon down to the same level every time!

Now make a different type of water lift. Replace one bottle with a taller, narrower bottle. Can a load in this new bottle be raised higher? What happens if you put the load in the other side?

Try making an oil lift. Pour the water out of both containers and replace it with cooking oil. Does this lift work as well or better than the water lift? Oil is messy stuff, so be sure to clean up thoroughly!



5. Position an inflated balloon on the surface of the water and gently push it down. As you push the water down on one side, it rises up the other side, lifting the load. The balloon acts as a piston. To raise the load even higher, you need to put more pressure on the balloon. Note the water levels in both bottles. If the water under the balloon goes down by a certain amount, how far does it go up on the other side?

5

SOARING FOUNTAINS

Water naturally flows downhill. The pull of gravity draws it down as low as possible. To spurt upwards, like the fountain shown here, water must be put under pressure. When hot rock from the Earth's core superheats underground water, a hot, steamy fountain called a geyser bursts skyward. Old Faithful in Yellowstone National Park, USA, rises 45m into the air every 70 minutes because of this pressure. (Certain lakes in Nainital and some other places in India too have water which is hotter than normal temperature.) A natural fountain will only rise as high as the water table which it feeds. Some natural fountains are fed by water from high lakes. You can and also prove that water pressure increases with depth, by building two projects shown here.

LIQUID JETS

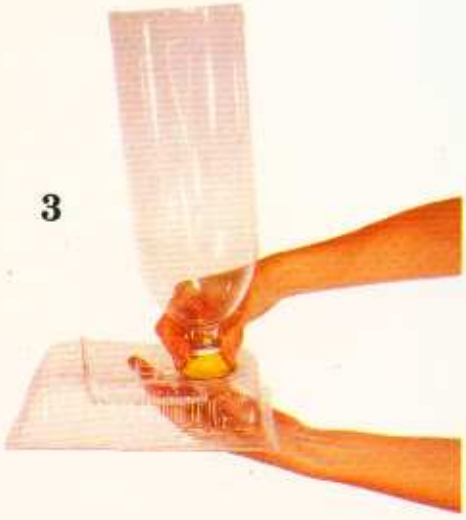
1

1. You need a plastic drinks bottle, two plastic straws, a plastic tray and some plasticine. Cut off the bottom of the bottle.

2. Seal the mouth closed with plasticine. Poke a straw through it as shown. Insert another straw through the open end of the first one.

2

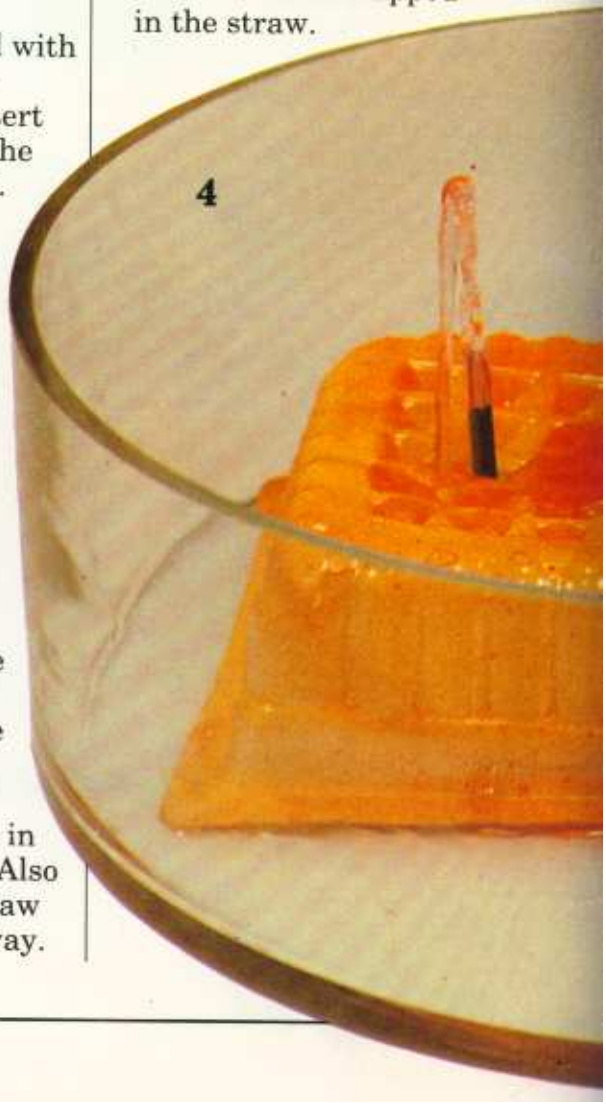
3



3. Pierce two holes in the plastic tray, one at each end of the base. Turn the bottle upside down and feed the straws through the holes. Seal the bottle in position with plasticine. Also fix the free end of the straw to the tray in the same way.

4. Place the tray and bottle inside a shallow container. Half fill the bottle with water. The pressure of this reservoir will cause a fountain to spurt through the straw if there are no air bubbles trapped in the straw.

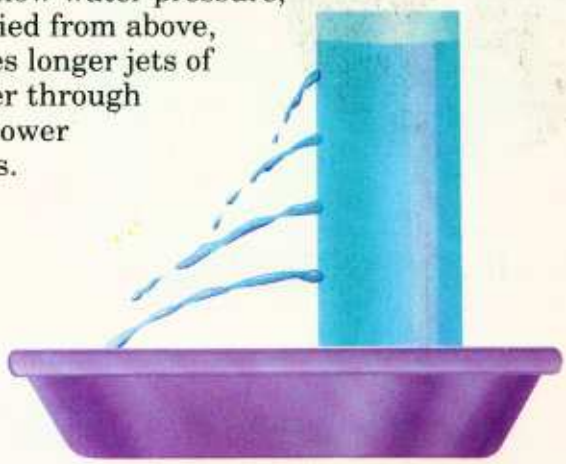
4



Bright Ideas

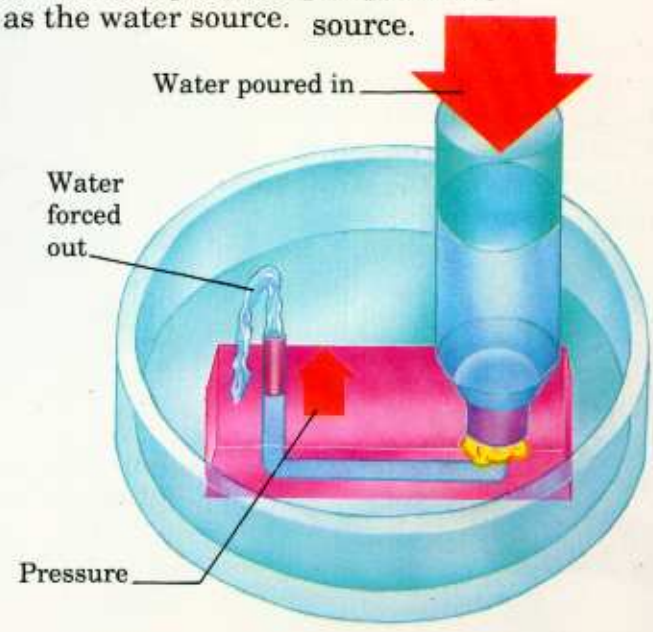
Add more water to the reservoir. What do you notice about the height of the jet from your fountain?

You can prove that the pressure of water increases with depth. Cut the top off a plastic bottle and make holes at different levels along one side. Put the bottle in a deep-sided dish. With your fingers cover the holes, and ask a friend to pour water in the bottle. When the bottle is full, release your fingers. See how water pressure, applied from above, forces longer jets of water through the lower holes.



Why It Works

Pressure from the water in your fountain reservoir pushes the water through the straw, causing it to spring into the air. The more you fill the reservoir, the greater the water pressure becomes and the higher the water will shoot up, striving to get as high as the water source. source.



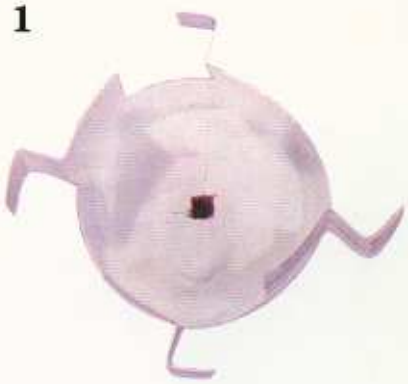
WATER ENGINEERING

For thousands of years people have used water's pushing power to drive machines. Since Roman times wooden water-wheels have run millstones to grind corn. Later water-wheels became the main power source for industry. One of the largest machines in the world, the modern water turbine, was developed from the water-wheel. Water turbines are connected to generators to produce hydro-electric power. In all water-wheels, the flow of water is directed around wheel blades to set the wheel spinning. The constant movement from the revolving wheel can then be put to work. You can make a water-wheel work for you. This one raises a bucket full of water.

WATER ENGINEERING

1. Cut the bottom from a liquid detergent bottle to make a water-wheel. Cut out 4 evenly spaced flaps around the sides of the bottle and fold them out as shown.

1



2

2. Make a hole in the base of the water-wheel and push a straw in. Fix it in place with plasticine. Cut a section from a drinks bottle large enough to put the water-wheel inside. Pierce two holes on either side of the bottle for the straw to pass through.

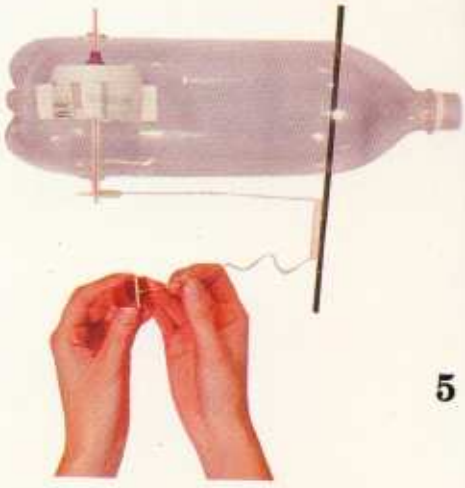
3

3. Fit the water-wheel into the cut-away section of the bottle, easing the straw through the holes. Poke tooth picks through the straw to secure it in place.

4. Make two holes through the top of the bottle and insesrt a pencil or chopstick. Tape a short piece of straw to the end of the pencil.

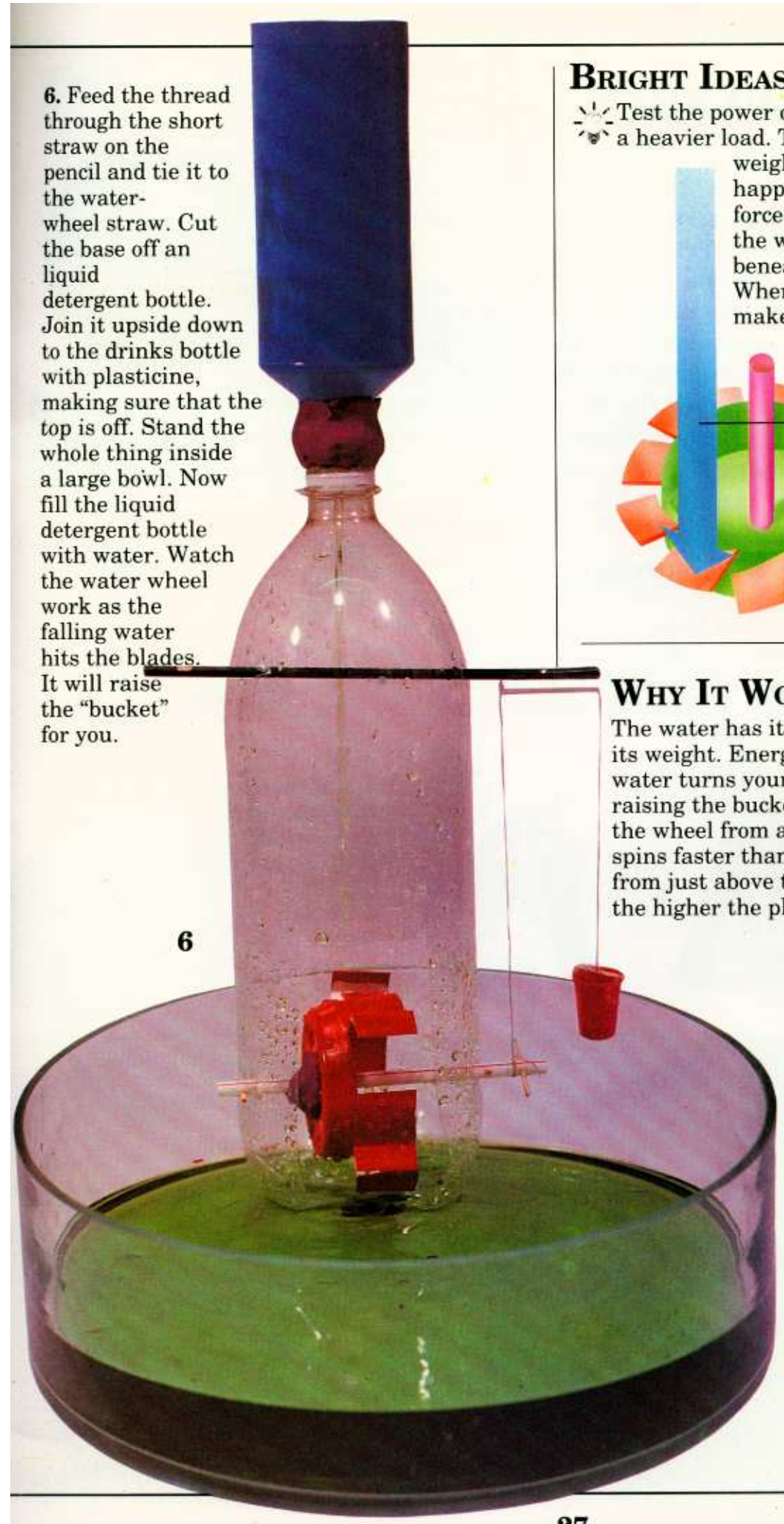
4

5. Make a bucket from a bottle cap. Glue a match stick across the top. Tie a thread to it.



5

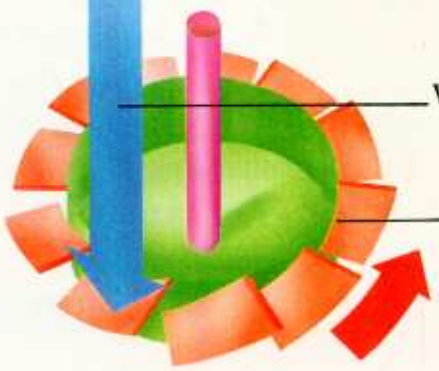
6. Feed the thread through the short straw on the pencil and tie it to the water-wheel straw. Cut the base off an liquid detergent bottle. Join it upside down to the drinks bottle with plasticine, making sure that the top is off. Stand the whole thing inside a large bowl. Now fill the liquid detergent bottle with water. Watch the water wheel work as the falling water hits the blades. It will raise the "bucket" for you.



6

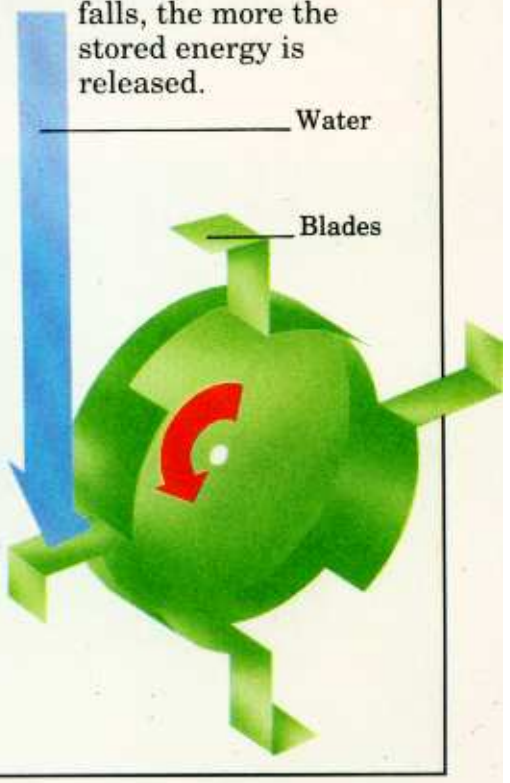
Bright Ideas

Test the power of your water-wheel with a heavier load. Try putting a small weight in the bucket. What happens when you increase the force of the water falling onto the wheel? Suspend the wheel beneath the flow from a tap. Where must you hold it to make it turn faster?



Why It Works

The water has its own pressure due to its weight. Energy from the fast-flowing water turns your water-wheel, in turn raising the bucket. If you pour water onto the wheel from a great height, the wheel spins faster than in case the water falls from just above the blades. This is because the higher the place from where the water falls, the more the stored energy is released.



Paddle Power

The first paddles used for moving vessels in water were probably simple oars. By the early nineteenth century the first steam-powered ships were fitted with paddles. As the paddle circled round and round, it pushed back the water with its blades. This action propelled the vessel forward. It was Issac Newton who first stated that for every action (in this case, the paddle pushing against the water), there is an equal and opposite reaction, (the vessel being propelled forward.) A British engineer, Isambard Kingdom Brunel, built the first iron ship to be driven by a screw propeller which, like the paddle, pushes the water backward and the ship forward. Even today paddle steamers, like the one shown here, carry tourists in some parts of Bihar and Bengal. You can make a model boat that is driven the same way.

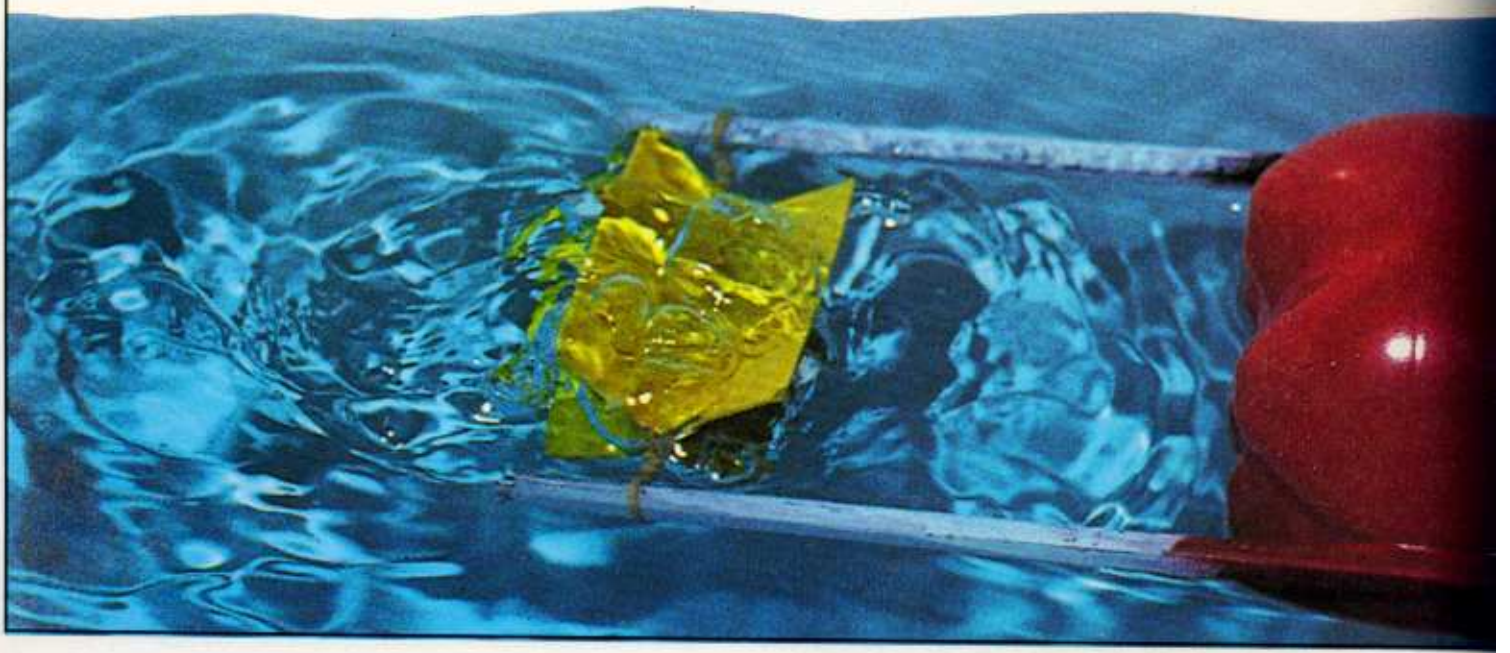
SPEEDY BOATS

1. Take a small plastic bottle with a top and cut a hole in one side, large enough for a cardboard tube. This cardboard tube will be the funnel of your paddle steamer.

2. Tape two sticks or pencils on either side of the bottle. They should stick out about 6cm past the bottom of the bottle.

3. Cut two rectangles from a fruit juice carton. Make sure that they are smaller than the base of the bottle.

4. Make a slit halfway down the middle of each. Slide them together to form a paddle.



Why It Works

The paddle boat is driven by the potential, or hidden energy stored in the elastic band. As the elastic unwinds, the paddle turns, pushing the water backwards and the boat forwards. The potential energy has been changed into kinetic, or moving energy.

Bright Ideas

Find out how far the boat travels in relation to the number of turns that you give the paddle. You can make a graph to show the results.

Does winding up the paddle in or out of the water make any difference?

Twist the paddle clockwise and note what happens when the boat moves. Now twist it anti-clockwise.

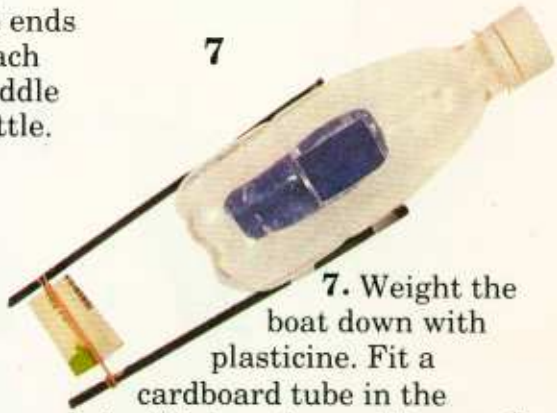
Fix a different elastic band to your boat. Does a tighter elastic change the boat's motion?

Make a propeller-driven boat. Does it go further or faster than a paddle-driven boat? Race your two different types of boat together in the bath.

6. Place the paddle wheel in between the sticks. Loop the ends of the elastic band around each stick. Make sure that the paddle wheel is not touching the bottle.

6

7



7. Weight the boat down with plasticine. Fit a cardboard tube in the hole. Wind up the paddle round the elastic and place the boat in the water. Let it go and watch it shoot forward.

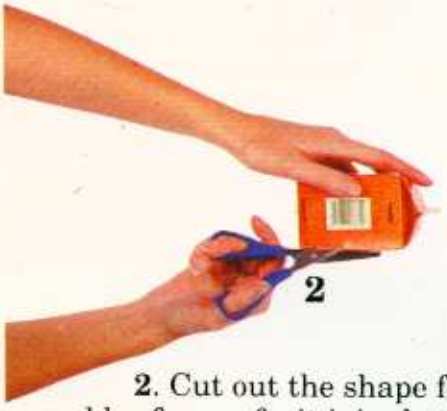
Steering and Balance

The Vikings used a single, hand-operated steering oar at the stern, or back, of their ships. It was always on the right- hand side, and that is how it came to be called steerboard or starboard. Stern rudders were first used over 1000 years ago on flat-bottomed Chinese junks. Modern propeller-driven submarines are steered by tail rudders. In order to manoeuvre up and down, they use hydroplane fins which look like aeroplane wings. Dolphins are propelled by their tail fins — the other fins are for balance and steering.

RUDDER DESIGN

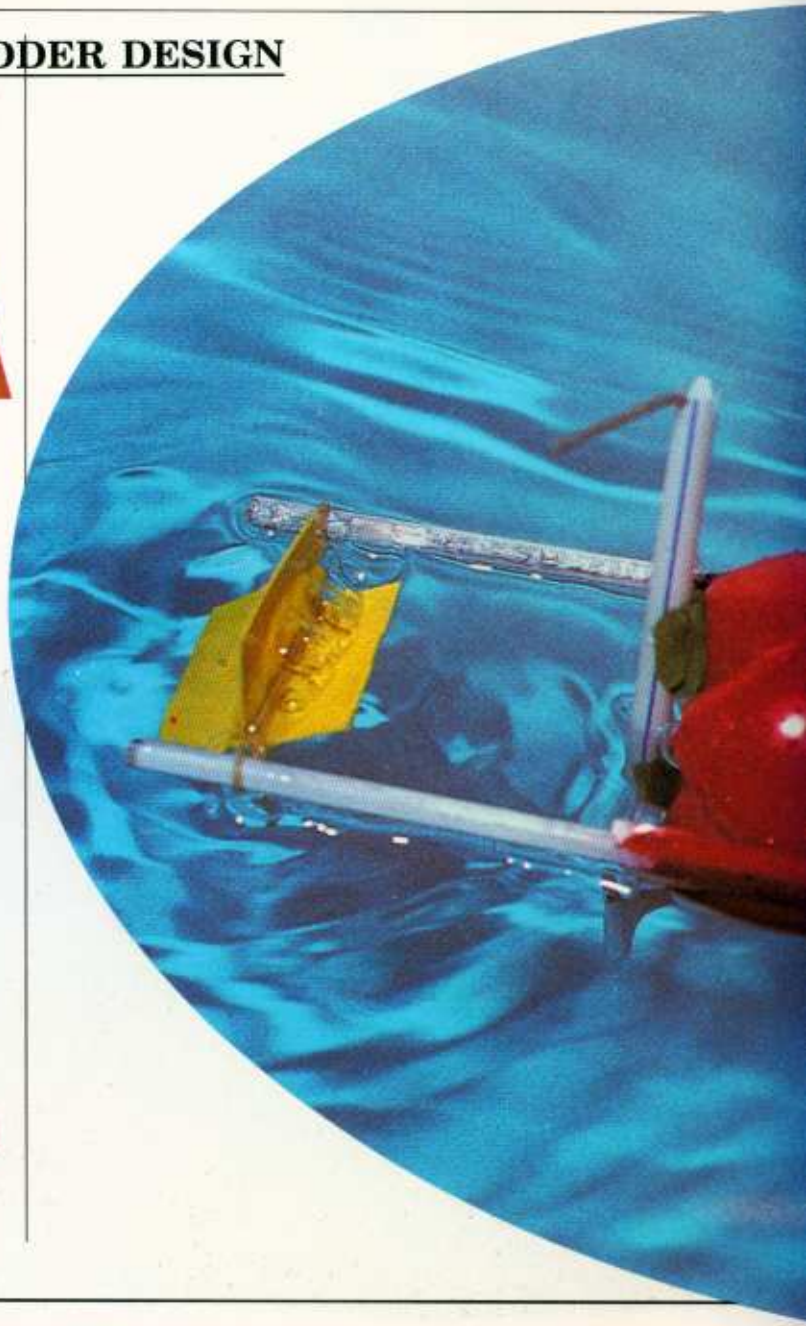
1. For your rudder's slide a pipe cleaner inside a straw, leaving a piece sticking out of the top for the handle and a piece at the bottom.

1

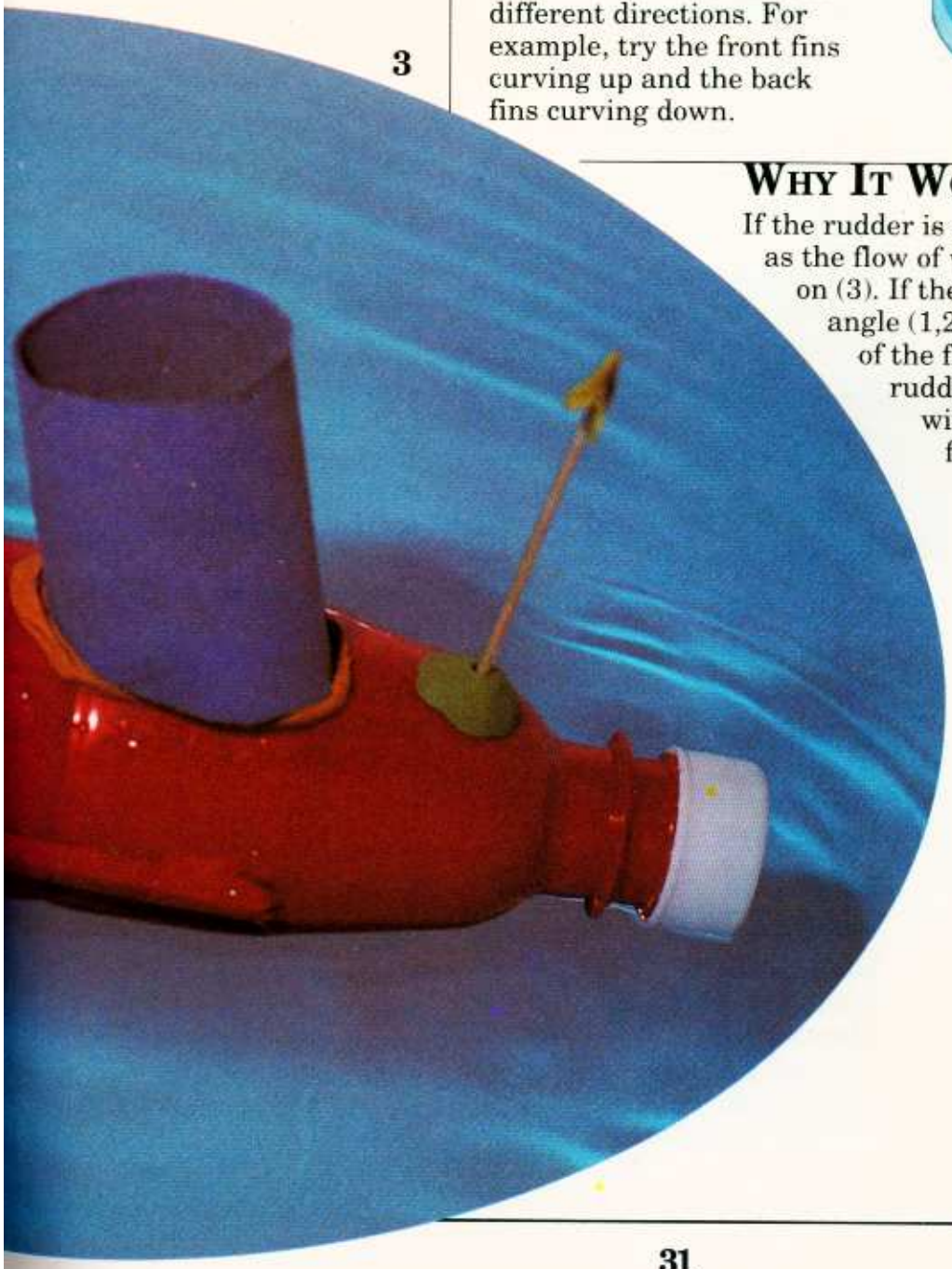


2

2. Cut out the shape for the rudder from a fruit juice bottle. Attach it to the straight end of the pipe cleaner. Make sure that it points in the opposite direction to the handle.



3. Fix the finished rudder to the back of your paddle boat with plasticine. Wind the paddle anti-clockwise to propel the boat through the water. Once it is moving, use the handle of the rudder to change the direction in which it travels. Keep a record of what happens. When you push the handle to the right, observe which way the rudder turns. At the same time notice which way this makes the boat turn.

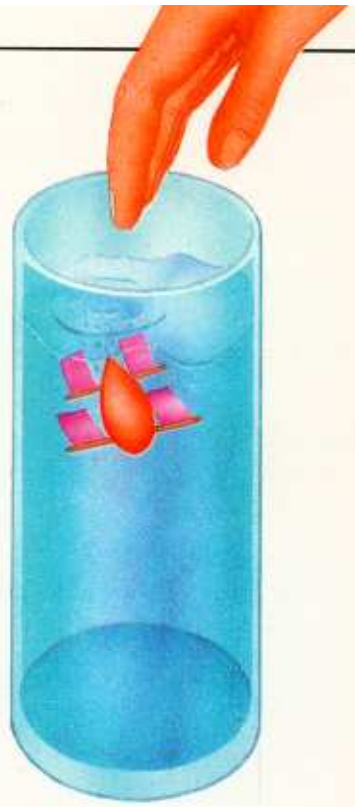


3

Bright Ideas

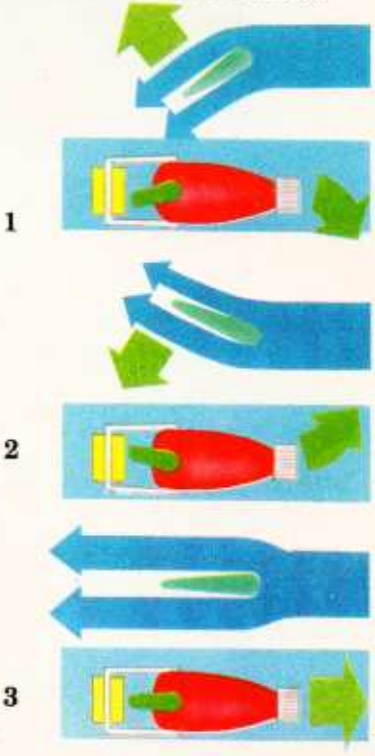
If you want to turn the boat to starboard, which way must you turn the rudder? Can you make your boat do a complete turn by operating the rudder?

Make a "submarine" and fit your adjustable, curved fins to the sides. To manoeuvre, or turn your vessel, experiment with the fins. With the back fins and the front fins curving in the same direction, gently drop the submarine in water. Now find out what happens when the fins are fixed in different directions. For example, try the front fins curving up and the back fins curving down.



Why It Works

If the rudder is pointing in the same direction as the flow of water, the ship moves straight on (3). If the flow strikes the rudder at an angle (1,2), the ship turns. As the force of the flow tries to push the angled rudder back to parallel, it is met with resistance— an opposing force which turns the boat.



Scientific Terms

AQUANAUT A person who works, swims or dives underwater.

BOILING POINT The temperature at which a liquid turns into a gas. For water, it is 100°C.

CAPILLARY ACTION The rising or falling of water in contact with a solid.

CONDENSATION The change of a gas, such as water vapour, into liquid drops.

DENSITY The heaviness of a substance for unit volume.

EVAPORATION The change of a liquid into a gas by the escape of molecules from its surface.

HYDRAULICS The technology of liquids in motion and at rest.

HYDROMETER An instrument for measuring the relative density of liquids.

MENISCUS The curved surface of water in a tube, produced by surface tension.

MOLECULE The smallest naturally occuring particle of a substance.

PLIMSOLL LINE A load line painted on the hull of a ship.

SALINITY Saltiness.

SURFACE TENSION The molecular force of a liquid that pulls it into the smallest possible area. It makes water drops round and forms a meniscus in a glass of water.

WATER VAPOUR The gas evaporated from the surface of liquid water. (Vapour from boiling water is called steam).

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